Nantucket Harbor Water Quality
Annual Report
2006

Prepared for:

Marine and Coastal Resources Department
34 Washington St.
Nantucket, MA. 02554

Prepared by:

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Introduction:

Nantucket Harbor has an approximate surface area of 5,250 acres and basin volume of 50, 990 acre-ft. Nantucket Harbor is comprised of three large basins each connected by a narrow race- way with two additional lobes, called Polpis Harbor. Within Nantucket Harbor, Polpis Harbor has a surface area of 177 acres and basin volume of 923 acre-ft. Polpis Harbor is a large collector of runoff from the harbor watershed, and as such, is a nutrient and bacteria source for Nantucket Harbor.

Water quality and circulation studies have been documented since 1990, and monitored to some extent prior. Woods Hole Institute, Ecosystems Consulting Service Inc. of CT., Aquatic Ecosystems, also from Ct., Applied Science Associates of RI., and The School of Marine Science and Technology under the Massachusetts Estuary Project under the direction of the Department of Environmental Protection have all done extensive investigations of Nantucket Harbor. Water quality results indicate that nutrients are increasing; and being recycled in the Head of the Harbor, and Quaise Basin. Polpis Harbor has contributed to the decline in water quality in Quaise Basin, as nutrients are continuing to be loaded from the harbor watershed. Though the Town area is sewered, the lower harbor area in some years is a large source of nitrogen and phosphorus. Runoff from the storm drains and Consue Srpings carry whatever contaminants may be in the surface water into the lower harbor. The Department of Public Works and Earth Tech will be working on a storm drain mitigation project in the spring of 2007. This will combine runoff into central systems, decrease the multitude of outflow pipes, and decrease the level of nutrients flowing into the lower harbor during storm events.

Nantucket is not alone in the degradation of its harbor water quality. There have been serious declines in water quality in all coastal communities due to anthropogenic nutrient overloading. Although coastal ecosystems have the capacity to assimilate some level of nutrient input without major changes in the ecological health, most coastal communities have exceeded this ability. The Town of Nantucket has made discernable efforts to understand and remediate this process of accelerated eutrophication, however a noticeable declining trend continues. The Town will continue to monitor these trends in order to mitigate these processes associated with development, and our uses of the Island's resources.

As nitrogen and phosphorus concentrations increase, the natural eutrophication process is accelerated. This process results in excessive aquatic plant growth (phytoplankton, macro and epiphytic algae); especially prevalent in a poorly flushed shallow coastal embayment. Photosynthesis is increased during the day, but respiration is also increased during the night. And when this over abundant plant growth dies, its decomposition uses up the available dissolved oxygen and increases the frequency of anoxic conditions. When anoxic events occur nutrients are released from the sediments back into the water column. The continued addition of nutrients and acceleration of plant growth leads to further decomposition by bacteria. The result is an embayment bottom coated with an organic mud residue (i.e. Wauwinet Basin, Quaise Basin, and Polpis). Light penetration decreases, eel grass diminishes, and a habitat once desirable for shellfish and finfish, is now unsuitable for spawning, development, and life.

For many years 1992-2004, the Marine and Coastal Resource Department biologist, Tracy Curley, gathered nutrient information for Nantucket Harbor and its' watershed drainage basin. Harbor sampling includes temperature, dissolved oxygen, salinity, water transparency, water quality constituents (nitrogen and phosphorus), and phytoplankton. Harbor monitoring also includes similar data collected from the streams that flow into the upper and middle harbor areas.

The Nantucket Harbor water quality stations are as follows: **Site 1:** Mooring Field, **Site 2:** Quaise Basin, **Site 3:** Head of Harbor, **Site 4:** Nantucket Sound, **Site 5:** Polpis West, and **Site 6:** Polpis East. These locations are designated on **Map #1**.

The stream stations are located on **Map #2**, and are as follows: **Stream 1:** flows into the Head of the Harbor, **Stream 2:** flows into Medouie Creek, **Stream 3:** flows into Polpis East, **Stream 4:** flows into Polpis East, draining Cranberry Bog, **Stream 5:** flows into Polpis West, draining swamp near cemetery, **Stream 6a:** flows into Polpis West, **Stream 6b:** flows into Polpis West, **Stream 6c:** flows into Polpis West, draining Duck Pond, **Stream 7:** flows into Quaise, **Stream 8:** flows into Fulling Mill Brook, next to the Life Saving Museum.

Harbor Monitoring Results:

Appendix A: contains all harbor water quality data. **Appendix B:** contains the averages of A with corresponding charts. **Appendix C:** contains physical stream data for the upper and middle harbor watershed. **Appendix D:** contains chemical stream data. **Appendix E:** contains the average total nitrogen and phosphorus loading from D. **Appendix F:** contains the average monthly rainfall for 2006, as collected by the Nantucket Water Company.

Average Temperatures and Average Dissolved Oxygen:

Nantucket Harbor is relatively isothermic, with little stratification of temperature between top and bottom. The harbor does warm faster in the spring, and cool faster in the fall, when compared to the sound. This is because its total volume is less than that of the sound, and more rapidly affected by sidereal conditions. Also because of this, for short periods in the spring, surface temperatures may be slightly warmer; and then slightly cooler conversely as winter sets in. A mild turnover may occur following extreme winters where the surface of the harbor has been covered with ice. The magnitude of the turnover will depend on the severity of the winter, the duration and thickness of the ice. Cooler water will sink, driving up bottom waters, rich with nutrients to the surface. More common on deep lakes, the result is a temporary isothermic condition, breaking up the normal stratification. This is not typically the case with Nantucket Harbor which is relatively shallow, and well mixed by wind and tidal action.

There was a little ice during the winter of 2006, when the harbor reached freezing temperatures for a couple of weeks in February. Temperature in this harbor is more relevant to biotic and anaerobic conditions. The metabolism of the fauna, and the nutrient requirements of the flora may be affected by extreme temperatures in either direction. The dissolved oxygen levels required to avoid nutrient recycling are the most prevalent issues, which are affected by higher temperatures. Cooler temperatures induce many species to go into a period of torpor or dormancy. The northern bay scallop for example exist in a period of cessation under 7º C, and spawn at temperatures around 22º C. Temperatures above 26º C for extended periods will increase the metabolic rate of these animals resulting in stress, which may bring about premature death. High temperatures did occur in 2006. During the last week of July and the first week of August, the upper harbor reached approximately 26º C; though no major die off of scallops was seen, nor was there any data taken showing signs of anoxia during the sampling events.

Photosynthesis creates plant growth during the day, which in turn generates oxygen in the water column. However, higher temperatures will decrease the solubility of oxygen in water. Dissolved oxygen is lowered by this process, it is further lowered by the process known as biological oxygen demand, generated from respiration occurring at night; and the consumption of oxygen by bacteria. Dissolved oxygen levels above 5 mg/l are a desirable condition for most aquatic species. Some species have a wide range of tolerances and may not be stressed until D.O. levels drop below 3 mg/l. Anoxic conditions exist when D.O. levels drop to 1 mg/l and below. Most fish, shellfish, and benthic organisms can not survive anoxic conditions for any length of time. A eutrophic state will also be increased as nutrients are released from soils during anoxic events, and nitrogen is recycled into the water column, (also known as internal recycling). The resultant affect of these conditions are the excessive blooms of phytoplankton, and the increased growth of epiphytic and macro algae. The excessive growth of these algae results in the shading of eel grass, which causes it to die. The increased organic matter eventually leads to an increase in nutrients, decreasing oxygen, and decreasing habitat (eel grass). The summer of 2006 sampling rounds showed temperatures above 26º C, however very few hypoxic events, and no anoxic events.

Figure1: AverageTemperatures2006

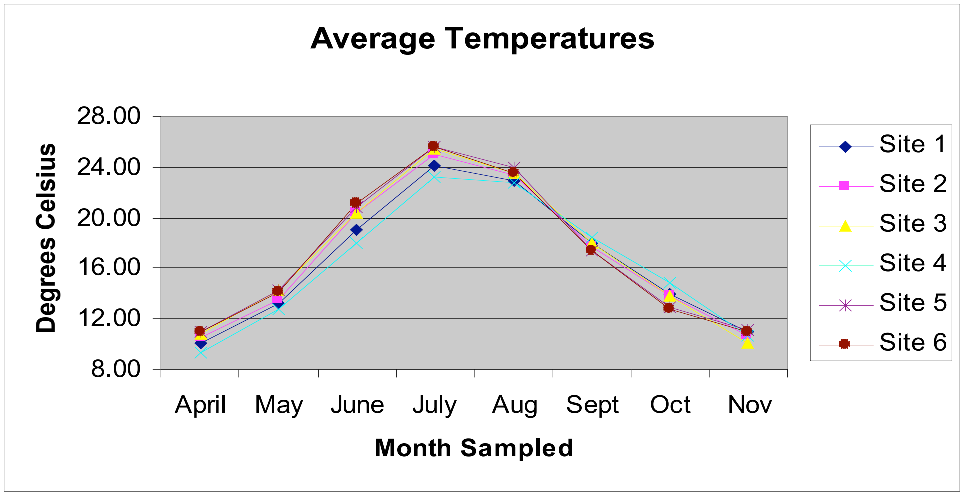
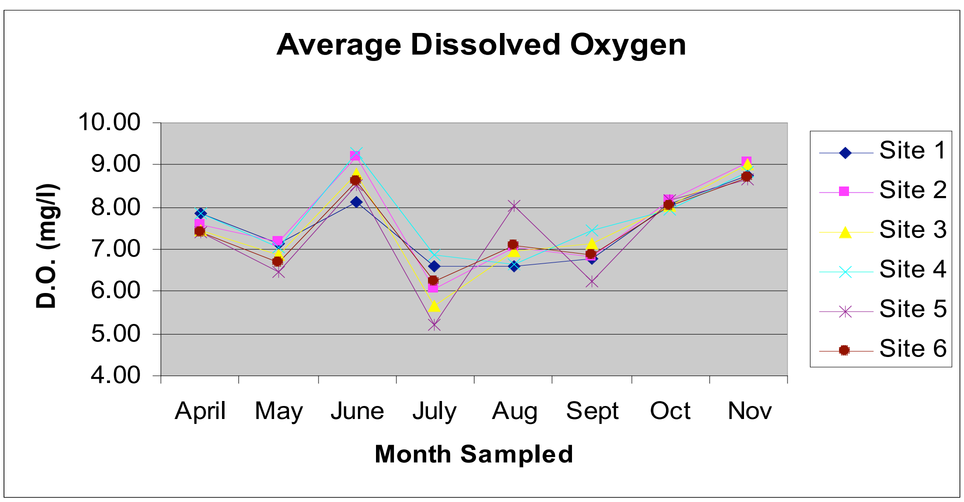


Figure 2: Average Dissolved Oxygen 2006

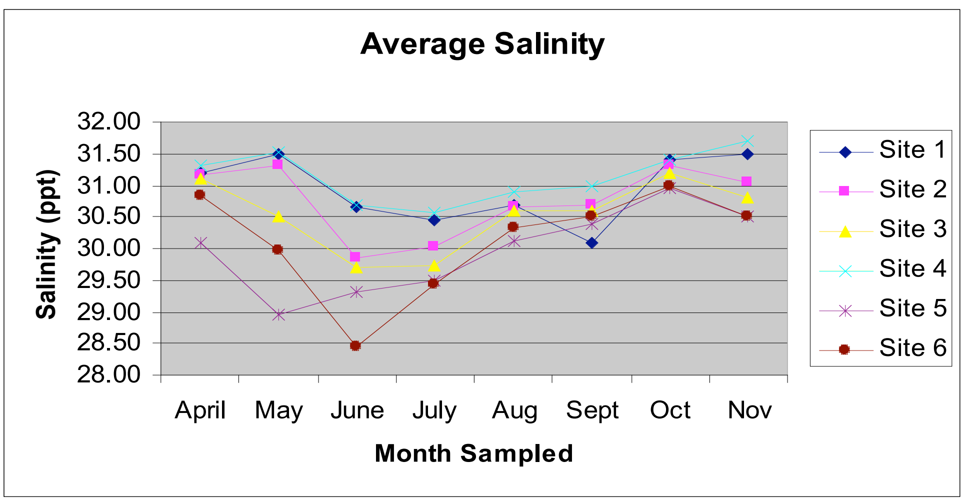


Salinity:

Average salinity in Nantucket Harbor is usually around 30 ppt (parts per thousand), average salinity in the open ocean is closer to 32 ppt. Salinity is important with respects to stratification, and biodiversity. As previously discussed the harbor is well mixed, the only area of exception to this is Polpis Harbor. This is because of the large amount of runoff occurring in a relatively small and enclosed area, the salinity gradients in Polpis vary widely from the open harbor. Stratification does occur here, and surface salinities have been measured as low as 24 ppt. Though relatively shallow, the difference between top and bottom may be as much as 6 ppt. Generally this occurs in Polpis West, as this is where most of the fresh water input occurs. Stratification was not well seen during the summer of 2006, however a recording as low as 27.8 ppt was seen in Polpis West during the May sampling event. Salinity and temperature stratifications may cause discontinuities in dissolved oxygen concentrations throughout the water column.

Different species of aquatic animals often require different salinities at different stages in their life cycles. As such many of these species can sustain variations of salinity ranges. This is best done as adults, however as juveniles, and as larvae, many species have definite salinity requirements. For example winter flounder in their early life cycle prefer salinities around 4 ppt., and herring require almost completely fresh water; as do many anadromous fish species. Oysters may live in salinities as low as 5 ppt., but other shellfish such as bay scallops, have salinity requirements that are much higher (25 ppt for normal development). Further, the larvae of bay scallops can not survive a drop in salinity below 28 ppt.

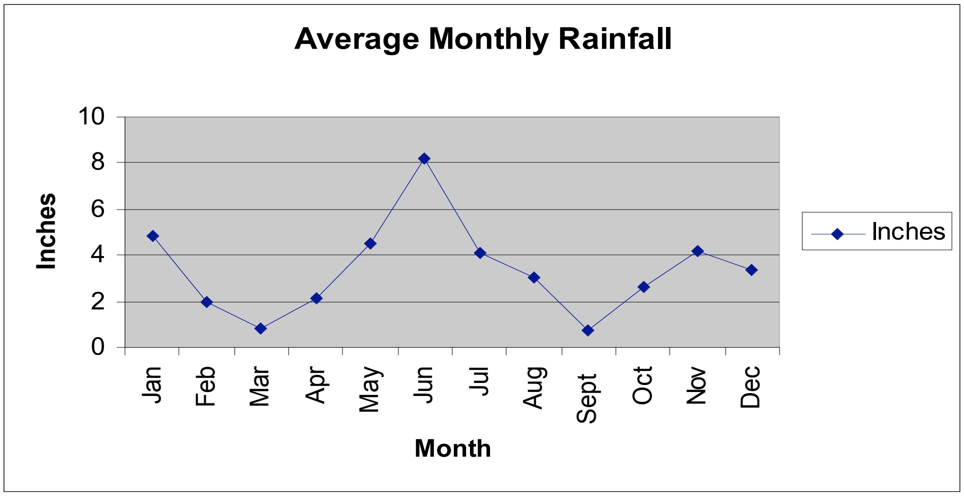
Figure 3: Average Salinity 2006



Rainfall:

Rainfall data corresponds well with salinities in Polpis, which were low in June, when 8.23” of precipitation was recorded. A large recoding such as this will increase runoff which may carry contaminated surface water to the harbor. Which may be extremely detrimental if occurring during sensitive time periods, such as the scallop spawn. Nitrogen and phosphorus levels will also be elevated increasing primary and secondary production, i.e. phytoplankton and macro-algae production. During the drier months salinities were noticeably the highest (Figure 3) and (Figure 4). Rainfall will also increase nutrient loading especially in shallow embayments with little circulation, or low flushing rates. This will be further discussed later in the section on nutrients, and the section on streams.

Figure 4: Average Monthly Rainfall 2006



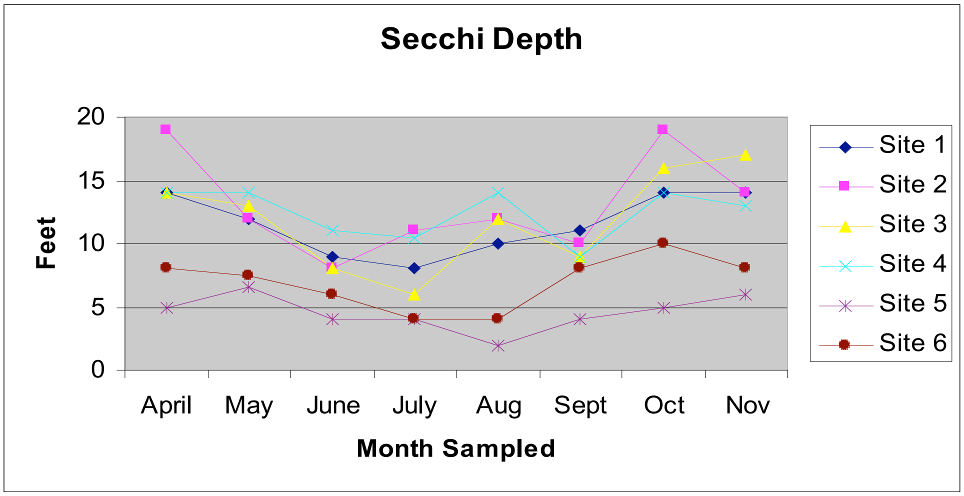
Secchi Depth:

Secchi depth is an approximate measurement of light penetration into the vertical water column. The recorded depth is roughly half the depth that sunlight will reach below the surface of the water. Below this depth photosynthesis is not possible, so a record of this information will provide a rough estimate of potential eel grass habitat. Water transparency is also largely a factor of phytoplankton production, as such it is an indicator of nutrients available in the water column. Generally there are two periods of maximum water clarity, (spring and fall) prior to and following two major blooms of phytoplankton. Usually these occur at the beginning of the spring, and just before the winter as water temperatures warm and cool dictating a change in phytoplankton communities.

Diatoms are the microscopic algae that make up the base of primary food production in the marine ecosystem. They provide the base of a food web upon which all other marine animals exist, and are normally the dominant species. However, if there is an excessive amount of nutrients and fresh water in a system, the development of a dinoflagellate community may evolve. In 2005 Nantucket experienced a "Red Tide", the toxic and potentially lethal dinoflagellate *Alexandrium tamerense* closed shellfish beds from 6/2 to 7/5. This was the first known incident for Nantucket, which participates in phytoplankton monitoring for the Division of Marine Fisheries. Extensive sampling for paralytic shellfish poisoning (PSP) found in *Alexandrium tamerense* continued in 2006, and fortunately no presence of this dinoflagellate was found. On 9/8 however a different toxic algae which also produces a red tide was seen. This dinoflagellate is called *Cochlodinium polykrikoides,* and is not poisonous to humans, but it is associated with fish kills. Fortunately this bloom was limited, and no fish kills were seen. The effects on shellfish species from *Cochlodinium polykrikoides* varies from species to species, and may be tolerated by some while causing retarded development in others.

Secchi depths were extremely high in April when harbor sampling began for 2006. Sites 5 and 6 are shallow water sites, and do not necessarily reflect secchi depth. When harbor sampling was discontinued for 2006 secchi depths had increased to initial sampling depths. The low secchi depths recorded for most of the summer reflect high nutrient availability. This is a result of loading from the watershed, loading from the atmosphere, and internal recycling. This was seen in the *Cochlodinium polykrikoides* bloom, and as bay scallops prefer diatoms it can be assumed that this was not good for the population in that area. There was an elevated period of clarity in August, which may be related to a drop in nitrogen and phosphorous; to be more thoroughly discussed in the section on nutrients. This clarity combined with a decline in precipitation, which followed a heavy flushing in June, thusly limited nutrient availability, and increased secchi depths accordingly.

Figure 5: Secchi Depth 2006



Nutrients:

Nitrogen:

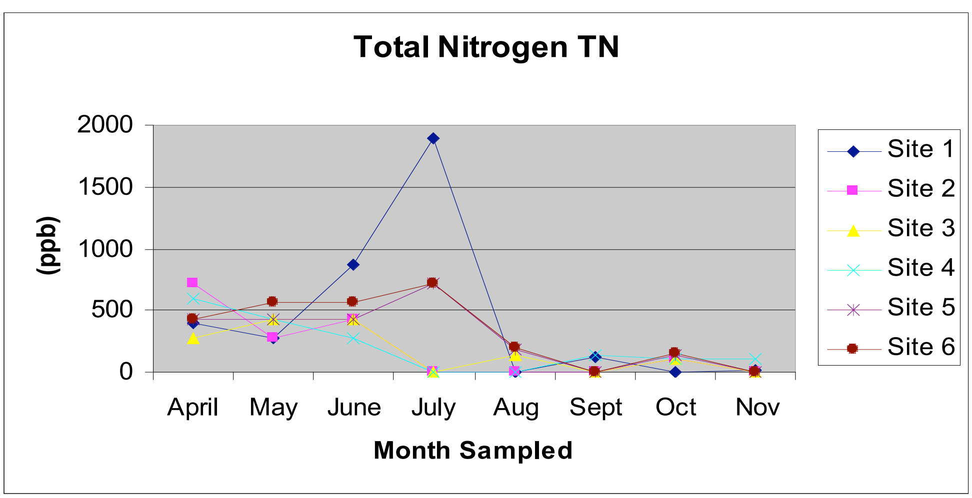
Nitrogen is the limiting nutrient in marine ecosystems, the quantity of which will dictate the health of any particular water body. Nitrogen is accumulating in Nantucket Harbor; and because of the harbors shape, the effects of nitrogen are more prevalent in some areas than others. Total nitrogen includes both organic and inorganic components. Ammonia or NH3 was the only constituent where the detectable limit was required to be lowered during lab analysis in order to approximate actual levels occurring in Nantucket Harbor. The lobes of Polpis and the various bends in the three major basins, have the capacity because of circulation patterns to trap nitrogen, and exhibit eutrophic conditions. The Department of Environmental Protection for Massachusetts uses some standard classifications based on nitrogen thresholds to describe the health of many marine ecosystems. Nantucket Harbor usually falls between the SA/SB category, showing some sings of moderate impairment, in some areas during the summer months. These standards can be found in the Estuaries Project Interim Report 2003.

Nitrogen values for Nantucket Harbor in 2006 range widely during the sampling period, from between 1,900 ppb TN in July, to non detectable limits for most of the later part of the months sampled. This indicates a range of poor to excellent water quality, which makes it difficult to discern the exact trophic state of the waters within. A total nitrogen value > 800 ppb would be an indication of “Sever Degradation” with a hypereutrophic state, and an "Impaired" classification; < 300 ppb would indicate excellent water quality. Most years the harbor is in a mesotrophic state, indicating a fair state with some impairment.

Nitrate NO3 values start high at sites 1 and 6 indicating impairment, however decline rapidly as temperatures increase and nutrients are rapidly used up during phytoplankton production. This may show a pre-existing condition of NO3 loading, and availability. Organic nitrogen values ranged roughly between 300 ppb – 500 ppb TKN initially then spiked to an unprecedented 1,900 ppb TKN at site 1 in July (Figure 6), following the extremely high level of precipitation in June. The largest drop in nitrogen in June was in the form of ammonia, probably due to its solubility. Following the June rains nitrogen drops off dramatically, most likely due to the flushing of the watershed from this extremely high level of precipitation. Sites 1 through 6 for the months August through November show nitrogen values 200 ppb TN and below, indicating excellent water quality. Again this is probably the result of an episodic event of high precipitation, and would not indicate a trend in the improvement of water quality in Nantucket Harbor; as uses in the watershed have not changed dramatically.

If severely degraded conditions are attained, water bodies will become extremely difficult to restore. A change in animal and plant communities may exist for long periods of time, a condition which in some towns along the Cape appears to be permanent. Fortunately Nantucket Harbor is still in good to fair condition, but harmful phytoplankton blooms are regularly occurring, and macro algae beds of Polysiphona, Grasscilaria, Cladophera, Ectocarpus, and others are becoming more prevalent. These macro algae are the result of increased nutrients, and can smother, and shade eel grass beds resulting in a loss of habitat for preferred marine organisms. Bacteria levels monitored by the Division of Marine Fisheries, maintain shellfish closures in the lower harbor; and these areas have increased in size. The Town of Nantucket assisted by the state is taking measures to correct this decline, and hopefully we are improving the conditions of the problem.

Figure 6: Total Nitrogen 2006



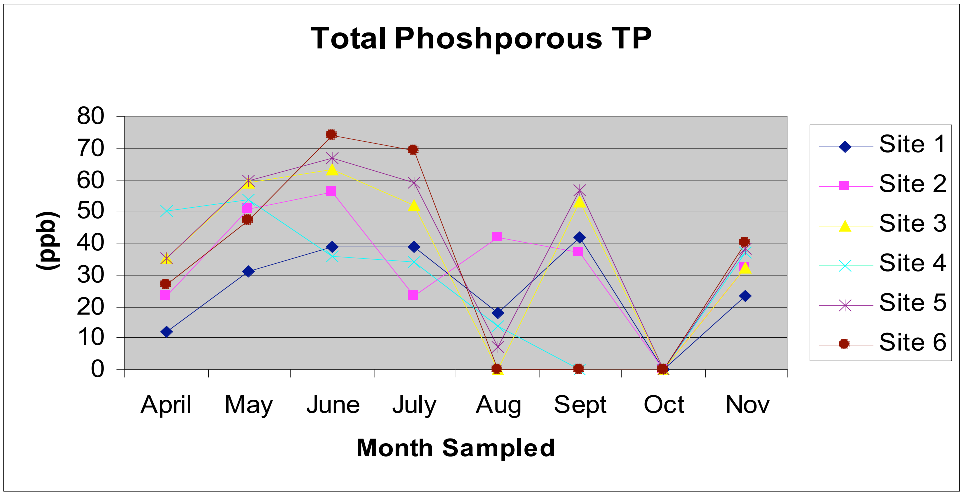
Phosphorous:

Phosphorous is a limiting nutrient in fresh water, but it is of relative concern to the marine ecosystem. An average ratio of nitrogen to phosphorous is 16:1. An over abundance of nitrogen or phosphorous will affect the type of phytoplankton species that will be dominant in any system. A shift or change in this ratio represents an imbalance, which may result in the overabundance of dinoflagellates. Diatoms are the preferred phytoplankton species, as most dinoflagellates are toxic to some degree. The level of total phosphorous becomes a problem when values around 50 ppb and higher become prevalent. This level would indicate a eutrophic condition; it would be associated with excessive undesirable plant growth, and anoxic events. A value of 25 ppb TP would be representative of a good/fair mesotrophic system with corresponding nitrogen values around 400 ppb.

Phosphorous, like nitrogen is naturally occurring, and would be expected at certain levels based on the geology of any given area. However, the influx of phosphorous from fertilizers, detergents, and septic systems will load a system, and upset the preferred balance. Usually the result is a preponderance of blue/green algae, which through its life cycle processes can choke a system; marine or fresh. Total phosphorous was consistently above 25 ppb for many monitoring sites throughout the summer. Many sites recorded levels above 50 ppb, suggesting an enriched condition for the harbor. Polpis sites were high as expected. However, not expected was a sharp decline in August at almost all sites except Quaise, Site 2. This corresponds to the sharp decline in TN at roughly this same time period, and may be the result of the same June precipitation / flushing event. This at first created an overabundance in nutrients, but was soon after followed by an uptake in phytoplankton and macro algae communities. This was then followed by a deficit or lag time in input, which delayed nutrient build up to reportable levels. Another sharp decline of TP at all sites occurred in October. This may be the result of changing anthropogenic uses, combined with a sharp decline in precipitation for the month of September. This would have created another lag time period, causing the delay of nutrients to reach the harbor through the watershed.

Loading usually begins in the spring, and lasts through to the end of the summer, when levels are highest. This is most likely related to the seasonal fluctuation of residents on Island, which does not peak until late June. The 2006 summer season was noticeably different, undoubtedly due to the uncommon level of rainfall in June. Though, other factors to be considered when evaluating inconsistencies are temperature, dissolved oxygen, and internal recycling.

Figure 7: Total Phosphorous 2006

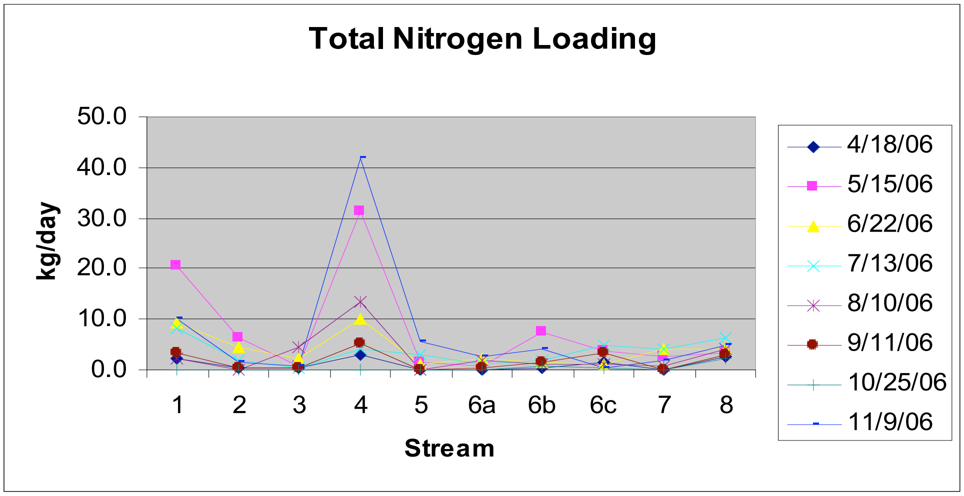


Streams:

The streams that enter into the head, and middle harbor areas are monitored to get an estimate on the amount of nutrient loading that is occurring in that watershed area (Map #2). The sampling is conducted once a month, and so may not accurately reflect a total maximum daily load. However when cross referenced with monthly precipitation, the amount of total nitrogen, and total phosphorous in kg/day is a relative factor in loading which needs to be monitored to establish existing conditions, trends, and changes. Stream data located in (Appendix C) shows that ground water temperatures are often cooler throughout the summer than harbor temperatures. Dissolved oxygen as expected is also lower. Water samples are taken on an ebb tide; and during dry months high salinities may be observed in Stream 1. High levels of total nitrogen and total phosphorous may be detected in the streams and may vary dependant on anthropogenic uses in the associated watersheds. As yet these areas are outside the Town Sewer District, however there are plans to inspect all septic systems in the harbor watershed in the near future (Nantucket Health Department).

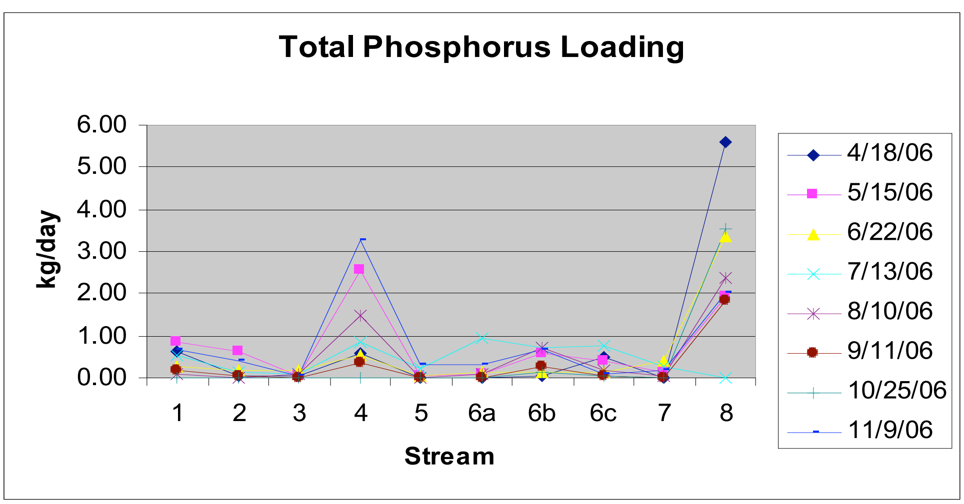
Stream 1 and 4 seem to be most affected by early rainfall, with respects to TN loading. Total nitrogen is extremely high at both sites for the May sampling round. Stream 4 shows the highest concentrated loading during the month of November; and is double the highest load shown in 2005. As this stream drains the cranberry bog, it would appear that the bog was having a direct influence and impact with regards to loading. Streams 3, 5, 6a, and 7 showed the least amount of loading for TN during all eight sampling rounds in 2006.

Figure 8: Total Nitrogen Loading from Streams 2006



Stream 8, had consistently high total phosphorous loading for seven sampling rounds in 2006, and may be receiving a constant load from some anthropogenic uses in its direct watershed area. Some increase or change in uses may have occurred, because the loading of TP in 2006 was near double the load in 2005. An elevated level of loading for TP also occurred in Stream 4, the highest of which coincide with the times of elevated TN loading. Precipitation was relatively high for May and November, 4.5" and 4.19" respectively. However those numbers are also relatively average for those time periods, and do not reflect an increase in TN, or TP loading in any of the other streams. Streams 1, 2, 3, 5, 6a, 6b, 6c, and 7 had relatively low levels of loading for all months, including June where the level of precipitation was nearly double that of May. Stream 4 therefore represents itself as one where some sort of filtration would be beneficial, prior to these waters entering Polpis Harbor, and subsequently Nantucket Harbor.

Figure 9: Total Phosphorous Loading from Streams 2006



- Stream data calculated and charted by Jeff Carlson, Beach Manager TON

Conclusion:

Nantucket Harbor remains in good/fair condition, and maintains the capacity to produce an abundant supply of recreationally and commercially harvestable shellfish and finfish. However there are sings of moderate impairment in certain places during the summer months, and this is regarded with great concern. The aesthetic and intrinsic value this natural resource holds can be seen in the property values in and around its watershed. The State and Town have undertaken great means to protect the integrity of the harbor. If managed well the viability of the harbor will remain intact. Soon to be released are reports and conclusions from the Urban Harbor Institute (Harbor Plan), Department of Environmental Protection directing the School for Marine Science and Technology in the Massachusetts Estuaries Project for (a total maximum daily load threshold management plan (TMDL)). Also, Earth Tech has been working with the Nantucket Department of public works on an island wide septage management plan, and will be retrofitting the lower harbor areas storm drains to main collection units this spring; all in an effort to improve water quality on Nantucket and in its harbors. The Marine Department will continue working with SMAST, and continue on its own sampling regime. Increased sampling will include chlorophyll to the quantitative analysis, and macro algae coverage to the qualitative analysis. Hopefully these efforts will ensure the safety of Nantucket Harbor for years to come.

Map #1: Nantucket Harbor Sampling Stations

Map #2: Stream Sampling Stations

Appendix A

Nantucket Harbor Physical and Chemical Data 2006

Site 1	Mooring Field
Site 2	Quaise Basin
Site 3	Head of Harbor
Site 4	Nantucket Sound
Site 5	Polpis West
Site 6	Polpis East

Temperature ºC

Site 1

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	10.2	13.4	19.5	24.4	23.1	18	13.9	11
3	10.2	13.4	19.4	24.4	23	18	14	11
6	10.1	13.3	19.4	24.4	23	18	14	11
9	10.1	13.2	19.3	24.3	23	18	14	11
12	10	13.1	18.9	23.9	22.9	17.9	14	11
15	10	13	18.5	23.7	22.9	17.9	14	11
18	10	13	18.5	23.6	22.8	17.9	14	11

Site 2

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	10.7	14	20.6	25.4	23.5	17.6	13.8	10.8
3	10.7	14	20.5	25.4	23.6	17.7	13.8	10.8
6	10.6	13.8	20.5	25.3	23.6	17.7	13.8	10.8
9	10.6	13.6	20.5	25.2	23.5	17.7	13.9	10.8
12	10.6	13.5	20.5	25.1	23.4	17.6	13.9	10.7
15	10.5	13.3	20.4	25	23.3	17.6	13.9	10.7
18	10.4	13.1	20.4	24.6	23.3	17.6	13.9	10.7
21	10.4	12.9	20.3	24.5	23	17.6	13.9	10.7
24	10.3	12.9	20.3	24.3	22.8	17.6	13.9	10.7

Site 3

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	10.9	14.3	20.5	25.7	23.6	18.2	13.8	10.3
3	10.8	14.3	20.5	25.7	23.6	18.2	13.8	10.2
6	10.8	14.3	20.5	25.4	23.6	18.1	13.8	10.2
9	10.8	14.2	20.5	25.4	23.6	18.1	13.8	10.2
12	10.8	14.2	20.4	25.3	23.5	18	13.8	10.1
15	10.8	14.1	20.4	25.3	23.5	17.9	13.7	10.1
18	10.7	14.1	20.4	25.3	23.4	17.8	13.7	10.1
21	10.7	14.1	20.3	25.2	23.3	17.9	13.6	10.1

Site 4

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	9.4	12.8	18.2	23.6	22.9	18.5	14.8	10.9
3	9.4	12.8	18.1	23.4	22.8	18.5	14.8	10.8
6	9.3	12.8	18	23.2	22.8	18.4	14.8	10.8
9	9.3	12.8	18	23.1	22.8	18.4	14.8	10.7
12	9.3	12.8	17.9	23	22.8	18.4	14.8	10.7
15	9.3	12.8	17.8	23	22.8	18.3	14.8	10.7
18	9.3	12.8	17.8	23	22.8	18.3	14.8	10.7

Site 5

	4/20/2006	5/24/2006	6/16/2005	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	11	14.6	20.9	26.2	24.1	17.4	12.8	11.1
3	10.9	14.3	20.8	25.5	24	17.4	12.8	11.1
6	11.1	14.1	20.6	25.3	23.8	17.5	13	11

Site 6

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	11.1	14.2	21.3	25.9	24.1	17.4	12.8	11.1
3	11	14.1	21.2	25.9	24	17.4	12.8	11.1
6	11	14	21.2	25.4	22.6	17.4	12.8	11
9	10.9	13.9	21.1	25.4	23.6	17.5	12.8	11

Dissolved Oxygen mg/l

Site 1

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	7.83	6.97	8.11	6.85	6.59	6.77	8.05	8.63
3	7.82	6.91	8.08	6.75	6.57	6.74	8.02	8.64
6	7.77	7.01	8.14	6.78	6.59	6.75	8	8.66
9	7.82	7.07	8.21	6.8	6.63	6.78	8.05	8.74
12	7.85	7.23	8.19	6.53	6.63	6.81	8.04	8.79
15	7.84	7.31	8.03	6.56	6.64	6.85	8.13	8.93
18	7.97	7.36	7.93	5.85	6.59	6.85	8.11	8.87

Site 2

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	7.53	6.94	9.15	6	7.02	6.74	8.12	8.85
3	7.58	6.94	9.13	5.98	7.01	6.69	8.09	8.83
6	7.57	6.97	9.13	5.99	7.03	6.69	8.11	8.91
9	7.58	7.04	9.16	6.04	7.14	6.71	8.15	8.94
12	7.59	7.14	9.22	6.02	7.16	6.74	8.17	8.99
15	7.63	7.19	9.24	6.08	7.05	6.82	8.19	9.05
18	7.61	7.28	9.26	6.08	7.02	6.95	8.26	9.08
21	7.62	7.34	9.25	6.34	7.6	7.04	8.27	9.13
24	7.67	7.39	9.25	5.85	6.17	6.68	8.03	9.19

Site 3

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	7.38	6.86	8.79	6.62	7.3	6.92	8.08	8.96
3	7.41	6.84	8.73	6.54	7.31	9.92	7.98	8.92
6	7.41	6.82	8.72	6.12	7.3	6.89	8.02	8.98
9	7.47	6.87	8.74	6.05	7.01	6.9	8.05	8.97
12	7.48	6.88	8.77	5.51	6.94	6.9	8.02	8.99
15	7.48	6.92	8.85	5.36	6.94	6.72	8.07	9.05
18	7.5	6.92	8.86	5.14	6.81	6.47	8.05	9.11
21	7.55	6.96	8.89	3.81	6.05	6.24	7.87	9.05

Site 4

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	7.86	7.02	9.17	6.39	6.58	7.35	7.91	8.84
3	7.81	6.97	9.16	6.61	6.58	7.31	7.86	8.76
6	7.81	7.01	9.22	6.96	6.61	7.35	7.9	8.77
9	7.84	7.03	9.22	6.95	6.66	7.42	7.92	8.82
12	7.86	7.01	9.23	7.02	6.69	7.53	7.95	8.87
15	7.87	7.06	9.44	7.05	6.72	7.57	8	8.92
18	7.87	7.09	9.52	7.09	6.74	7.62	8.05	8.98

Site 5

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	7.37	6.09	8.48	5.37	7.96	6.09	8.19	8.63
3	7.35	6.61	8.46	5.11	7.99	6.33	8.12	8.55
6	7.44	6.75	8.59	5.14	8.1	6.25	8.14	8.79

Site 6

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	7.39	6.63	8.62	6.07	7.76	6.76	8.16	8.67
3	7.41	6.62	8.58	6.01	7.09	6.77	8.01	8.67
6	7.42	6.73	8.55	6.45	6.8	6.8	8.01	8.67
9	7.39	6.82	8.63	6.42	6.75	7.16	7.89	8.84

Salinity ppt.

Site 1

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	31.2	31.5	30.6	30.4	30.7	30.1	31.4	31.5
3	31.2	31.5	30.6	30.4	30.7	30.1	31.4	31.5
6	31.2	31.5	30.7	30.5	30.7	30.1	31.4	31.5
9	31.2	31.5	30.7	30.5	30.7	30.1	31.4	31.5
12	31.2	31.5	30.7	30.5	30.7	30.1	31.4	31.5
15	31.2	31.5	30.7	30.4	30.7	30.1	31.4	31.5
18	31.2	31.5	30.7	30.4	30.7	30.1	31.4	31.5

Site 2

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	31.1	31	29.8	29.8	30.6	30.6	31.3	31
3	31.1	31	29.8	29.8	30.6	30.6	31.3	31
6	31.1	31.1	29.8	29.9	30.6	30.7	31.3	31
9	31.1	31.1	29.8	29.9	30.6	30.7	31.3	31
12	31.2	31.3	29.8	30	30.6	30.7	31.3	31
15	31.2	31.5	29.9	30	30.7	30.7	31.3	31
18	31.2	31.5	29.9	30.3	30.7	30.7	31.3	31
21	31.2	31.6	29.9	30.3	30.7	30.8	31.3	31.2
24	31.2	31.6	29.9	30.3	30.7	30.8	31.3	31.2

Site 3

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	31.1	30.5	29.7	29.7	30.6	30.6	31.2	30.8
3	31.1	30.5	29.7	29.7	30.6	30.6	31.2	30.8
6	31.1	30.5	29.7	29.7	30.6	30.6	31.2	30.8
9	31.1	30.5	29.7	29.7	30.6	30.6	31.2	30.8
12	31.1	30.5	29.7	29.7	30.6	30.6	31.2	30.8
15	31.1	30.5	29.7	29.7	30.6	30.6	31.2	30.8
18	31.1	30.5	29.7	29.8	30.6	30.6	31.2	30.8
21	31.1	30.6	29.7	29.8	30.5	30.6	31.2	30.8

Site 4

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	31.3	31.5	30.7	30.6	30.9	31	31.4	31.7
3	31.3	31.5	30.7	30.7	30.9	31	31.4	31.7
6	31.3	31.5	30.7	30.6	30.9	31	31.4	31.7
9	31.3	31.5	30.7	30.6	30.9	31	31.4	31.7
12	31.3	31.5	30.7	30.5	30.9	31	31.4	31.7
15	31.3	31.6	30.7	30.5	30.9	31	31.4	31.7
18	31.3	31.6	30.7	30.5	30.9	31	31.4	31.7

Site 5

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	30.1	27.8	29.2	29.3	30.1	30.2	30.9	30.5
3	30.1	29.3	29.3	29.6	30.2	30.5	30.9	30.5
6	30.1	29.8	29.4	29.6	30.1	30.5	31.1	30.5

Site 6

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
0	30.8	29.8	28.4	29.3	30.3	30.5	31	30.5
3	30.8	29.9	28.4	29.4	30.4	30.5	31	30.5
6	30.9	30.1	28.5	29.5	30.3	30.5	31	30.5
9	30.8	30.1	28.5	29.5	30.3	30.5	31	30.5

Secchi
ft.

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
Site 1	14	12	9	8	10	11	14	14
Site 2	19	12	8	11	12	10	19	14
Site 3	14	13	8	6	12	9	16	17
Site 4	14	14	11	10.5	14	9	14	13
Site 5	5	6.5	4	4	2	4	5	6
Site 6	8	7.5	6	4	4	8	10	8

Nitrate NO3 ppb

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
Site 1	120	BRL	30	BRL	BRL	BRL	BRL	BRL
Site 2	30	BRL	BRL	BRL	BRL	BRL	BRL	BRL
Site 3	BRL	BRL	BRL	BRL	BRL	20	BRL	BRL
Site 4	30	BRL	BRL	BRL	BRL	20	BRL	BRL
Site 5	30	BRL	10	BRL	BRL	30	BRL	BRL
Site 6	140	BRL	10	BRL	BRL	20	40	BRL

Organic Nitrogen TKN ppb

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
Site 1	280	280	840	1900	ND	100	ND	110
Site 2	420	280	420	ND	ND	ND	110	ND
Site 3	280	420	420	ND	140	ND	100	ND
Site 4	560	420	280	ND	ND	100	110	110
Site 5	420	420	420	700	190	ND	130	ND
Site 6	280	560	560	720	200	ND	110	ND

Total Nitrogen TN
ppb

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
Site 1	400	280	870	1900	ND	120	ND	11
Site 2	720	280	420	ND	ND	ND	110	ND
Site 3	280	420	420	ND	140	ND	100	ND
Site 4	590	420	280	ND	ND	140	110	110
Site 5	420	420	430	720	190	ND	130	ND
Site 6	420	560	570	720	200	ND	150	ND

Ammonia NH_3 ppb

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
Site 1	ND	ND	ND	23	20	30	ND	60
Site 2	ND	21	ND	71	40	20	30	60
Site 3	ND	37	ND	77	70	20	30	90
Site 4	97	30	ND	52	90	50	60	40
Site 5	56	42	ND	81	50	ND	ND	80
Site 6	34	47	ND	76	70	ND	30	50

Total Phosphorous TP ppb

	4/20/2006	5/24/2006	6/19/2006	7/31/2006	8/17/2006	9/13/2006	10/17/2006	11/30/2006
Site 1	12	31	39	39	18	42	BRL	23
Site 2	23	51	56	23	42	37	BRL	32
Site 3	35	59	63	52	BRL	53	BRL	32
Site 4	50	54	36	34	14	BRL	BRL	37
Site 5	35	60	67	59	7	57	BRL	38
Site 6	27	47	74	69	BRL	BRL	BRL	40

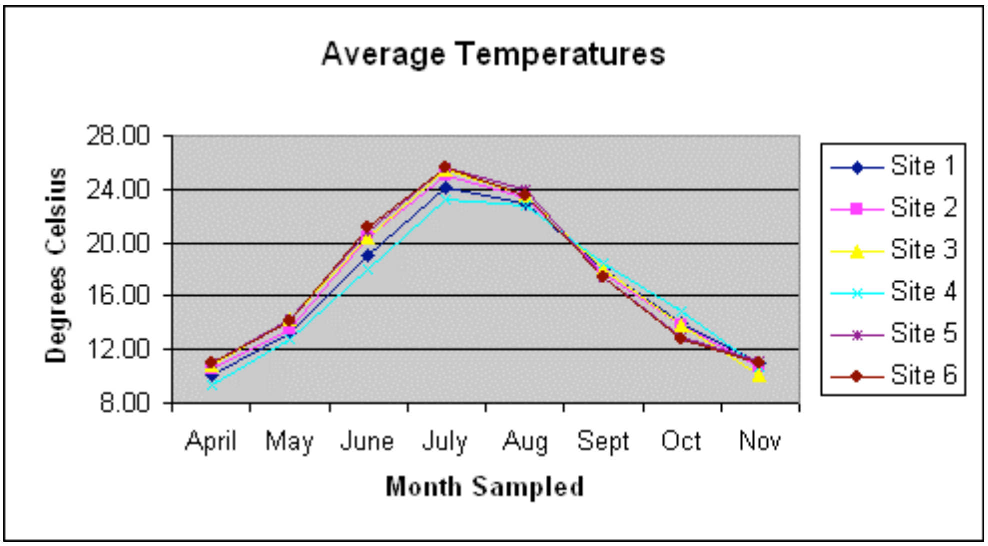
BRL = below reportable limit
ND = not detected / below detectable limit

Appendix B

Nantucket Harbor Average Physical and Chemical Parameters 2006

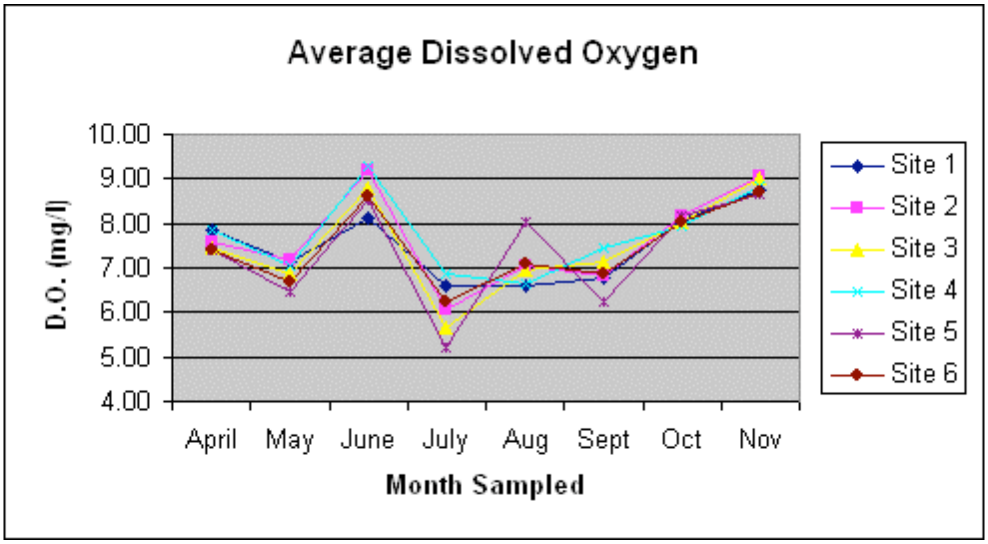
Temperature ºC

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	10.09	13.20	19.07	24.10	22.96	17.96	13.99	11.00
Site 2	10.53	13.46	20.44	24.98	23.33	17.63	13.87	10.74
Site 3	10.79	14.20	20.44	25.41	23.51	18.03	13.75	10.16
Site 4	9.33	12.80	17.97	23.19	22.81	18.40	14.80	10.76
Site 5	11.00	14.33	20.77	25.67	23.97	17.43	12.87	11.07
Site 6	11.00	14.05	21.20	25.65	23.58	17.43	12.80	11.05



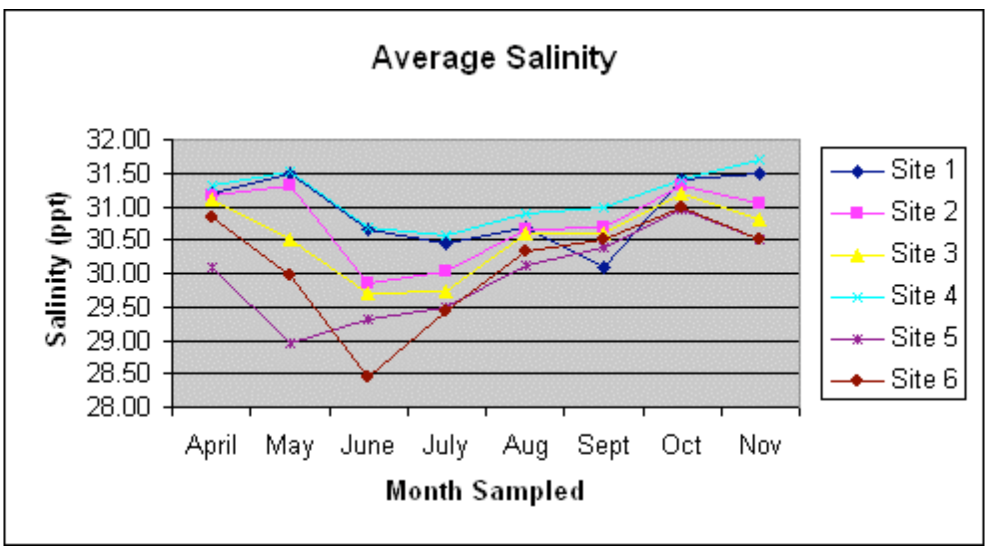
Dissolved Oxygen mg/l

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	7.84	7.12	8.10	6.59	6.61	6.79	8.06	8.75
Site 2	7.60	7.19	9.22	6.06	7.02	6.80	8.17	9.04
Site 3	7.46	6.88	8.79	5.64	6.96	7.12	8.02	9.00
Site 4	7.85	7.03	9.28	6.87	6.65	7.45	7.94	8.85
Site 5	7.39	6.48	8.51	5.21	8.02	6.22	8.15	8.66
Site 6	7.40	6.70	8.60	6.24	7.10	6.87	8.02	8.71



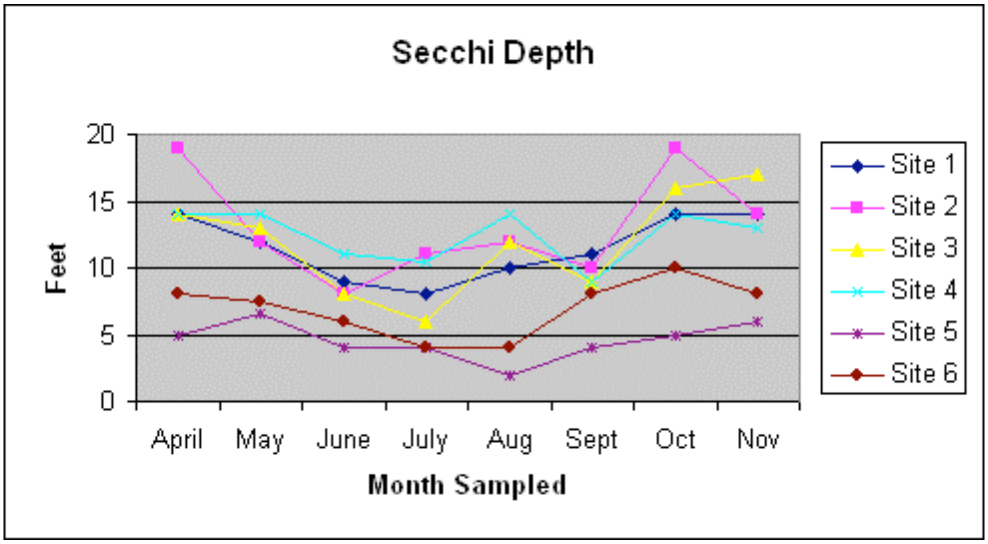
Salinity ppt.

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	31.20	31.50	30.67	30.44	30.70	30.10	31.40	31.50
Site 2	31.16	31.30	29.84	30.03	30.64	30.70	31.30	31.04
Site 3	31.10	30.51	29.70	29.73	30.59	30.60	31.20	30.80
Site 4	31.30	31.53	30.70	30.57	30.90	31.00	31.40	31.70
Site 5	30.10	28.97	29.30	29.50	30.13	30.40	30.97	30.50
Site 6	30.83	29.98	28.45	29.43	30.33	30.50	31.00	30.50



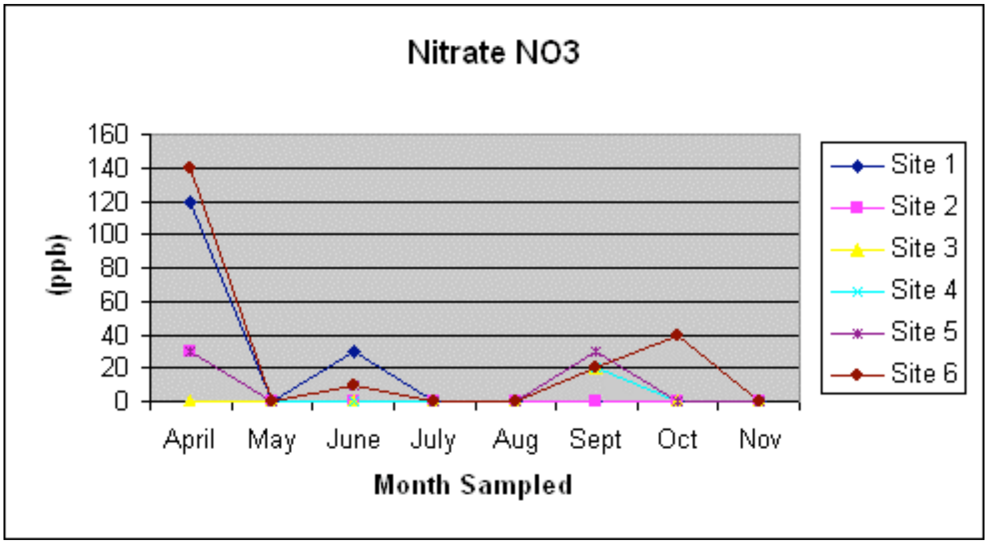
Secchi
ft.

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	14	12	9	8	10	11	14	14
Site 2	19	12	8	11	12	10	19	14
Site 3	14	13	8	6	12	9	16	17
Site 4	14	14	11	10.5	14	9	14	13
Site 5	5	6.5	4	4	2	4	5	6
Site 6	8	7.5	6	4	4	8	10	8



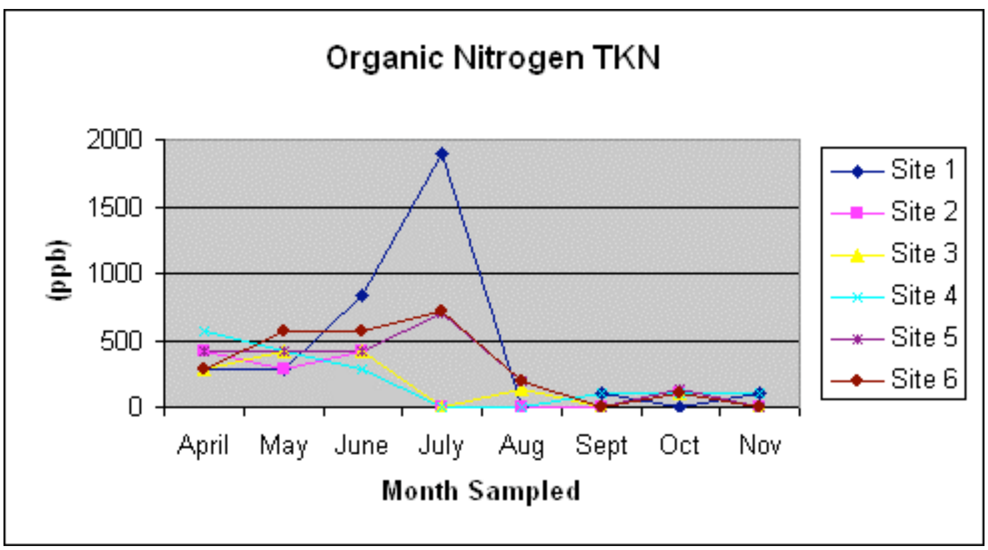
Nitrate NO3 ppb

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	120	BRL	30	BRL	BRL	BRL	BRL	BRL
Site 2	30	BRL	BRL	BRL	BRL	BRL	BRL	BRL
Site 3	BRL	BRL	BRL	BRL	BRL	20	BRL	BRL
Site 4	30	BRL	BRL	BRL	BRL	20	BRL	BRL
Site 5	30	BRL	10	BRL	BRL	30	BRL	BRL
Site 6	140	BRL	10	BRL	BRL	20	40	BRL



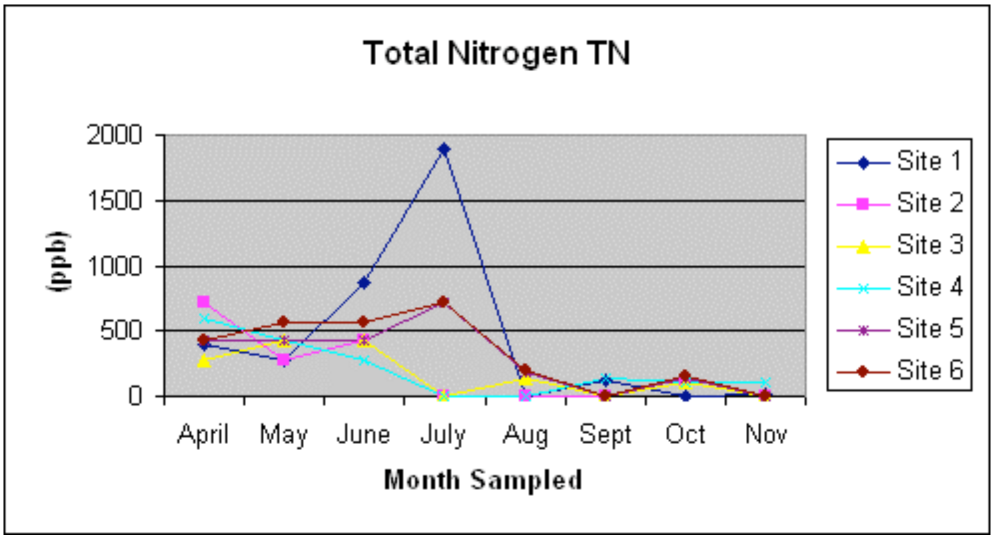
Kjeldhal Nitrogen TKN ppb

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	280	280	840	1900	ND	100	ND	110
Site 2	420	280	420	ND	ND	ND	110	ND
Site 3	280	420	420	ND	140	ND	100	ND
Site 4	560	420	280	ND	ND	100	110	110
Site 5	420	420	420	700	190	ND	130	ND
Site 6	280	560	560	720	200	ND	110	ND



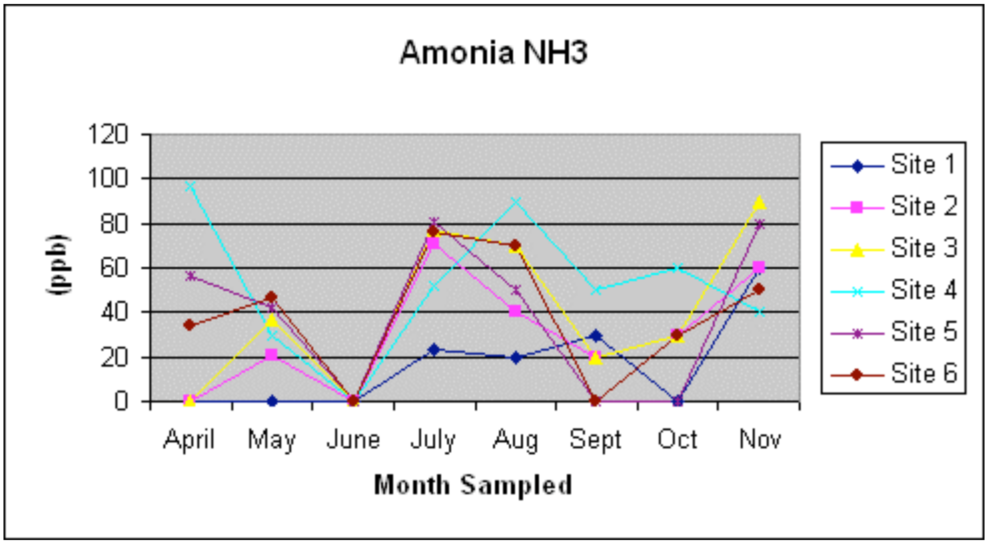
Total Nitrogen TN ppb

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	400	280	870	1900	ND	120	ND	11
Site 2	720	280	420	ND	ND	ND	110	ND
Site 3	280	420	420	ND	140	ND	100	ND
Site 4	590	420	280	ND	ND	140	110	110
Site 5	420	420	430	720	190	ND	130	ND
Site 6	420	560	570	720	200	ND	150	ND



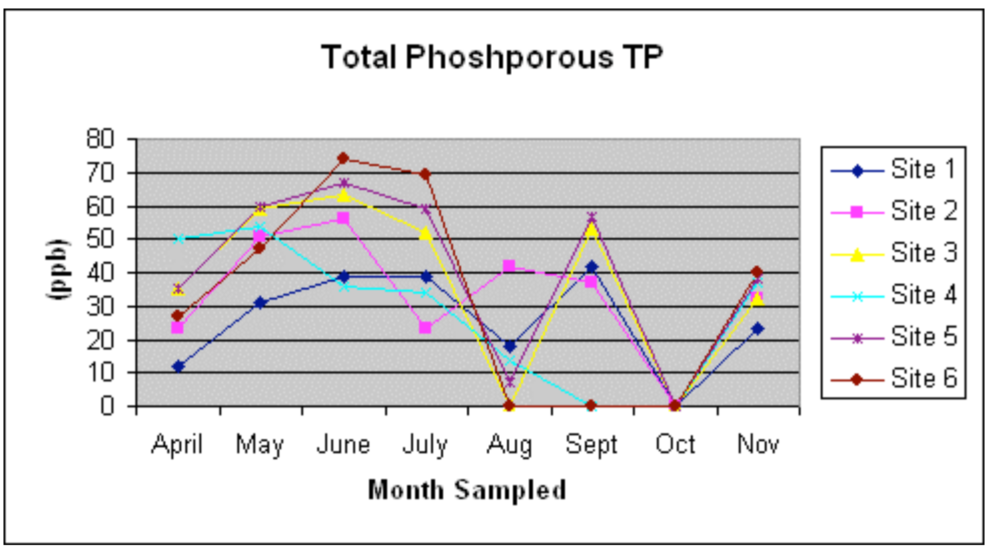
Ammonia NH3 ppb

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	ND	ND	ND	23	20	30	ND	60
Site 2	ND	21	ND	71	40	20	30	60
Site 3	ND	37	ND	77	70	20	30	90
Site 4	97	30	ND	52	90	50	60	40
Site 5	56	42	ND	81	50	ND	ND	80
Site 6	34	47	ND	76	70	ND	30	50



Total Phosphorous TP ppb

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	12	31	39	39	18	42	BRL	23
Site 2	23	51	56	23	42	37	BRL	32
Site 3	35	59	63	52	BRL	53	BRL	32
Site 4	50	54	36	34	14	BRL	BRL	37
Site 5	35	60	67	59	7	57	BRL	38
Site 6	27	47	74	69	BRL	BRL	BRL	40



Appendix C

Physical Stream Data 2006

1: flows into the Head of the Harbor
2: flows into Medouie Creek
3: flows into Polpis East
4: flows into Polpis East, draining Cranberry Bog
5: flows into Polpis West, draining swamp near cemetary
6a: flows into Polpis West
6b: flows into Polpis West
6c: flows into Polpis West, draining Duck Pond
7: flows into Quaise
8: flows into Fulling Mill Brook, next to Life Saving Museum

Temperature ºC

Stream	4/18/06	5/15/06	6/22/06	7/13/06	8/10/06	9/11/06	10/25/06	11/9/06
1	8.6	11	17.5	20.2	18.7	15.1	8.1	11.9
2	9.4	11.2	17.7	20.2	D	16.1	D	11.5
3	9.8	11.8	19.2	20.6	19.4	15.8	10.3	12.2
4	9	11.7	20.2	21.7	20.2	15.9	9.6	12
5	8.5	11.2	16.4	19.2	18.5	S	D	12.1
6a	9.1	12.2	18.4	20.3	18.2	15.4	8.5	12.2
6b	8.9	11.9	17.5	19.8	21.1	15	9.1	11.7
6c	10.4	13.6	22.4	22.2	21.1	16.3	10.1	13.1
7	9.2	12.7	18.7	20.5	20.7	S	D	12.7
8	10	13.3	18.6	18	18.3	15.6	10.1	12.4

Dissolved Oxygen mg/l

Stream	4/18/06	5/15/06	6/22/06	7/13/06	8/10/06	9/11/06	10/25/06	11/9/06
1	6.23	6.31	4.99	4.51	4.97	5.62	4.95	6.45
2	1.56	4.54	1.21	0.42	D	0.91	D	1.81
3	6.03	6.96	4.72	3.71	2.32	2.94	4.24	5.07
4	3.76	4.89	3.18	1.94	0.39	2.19	3.56	6.82
5	3.14	4.26	1.8	0.86	0.57	S	D	3.65
6a	5.17	4.81	2.13	2.5	0.78	1.92	1.53	5.26
6b	7.02	6.23	4.42	3.95	4.4	4.78	6.2	7.64
6c	7.69	7.32	7.11	6.84	0.39	4.35	7.11	6.68
7	2.77	3.58	0.8	0.4	0.59	S	D	1.07
8	5.84	6.11	5.84	3.59	3.59	4.67	5.51	5.27

Salinity ppt.

Stream	4/18/06	5/15/06	6/22/06	7/13/06	8/10/06	9/11/06	10/25/06	11/9/06
1	0.1	0.1	0.1	0.1	0	0.1	0.1	0.1
2	0.1	0	0	0.1	D	0.1	D	0.1
3	0.1	0	0	0.1	0.1	0.1	0.1	0.1
4	0.1	0	0	0	0	0	0	0.1
5	0.1	0	0	0	0	S	D	0.1
6a	0	0	0.1	0	0	0	0	0.1
6b	0	0	0	0	0	0	0	0
6c	0	0	0	0	0.1	0	0	0
7	0.1	0	0.1	0.1	0	S	D	0.1
8	2.2	1.8	0.7	3.8	3.4	2.2	2.3	3.1

Conductivity us

Stream	4/18/06	5/15/06	6/22/06	7/13/06	8/10/06	9/11/06	10/25/06	11/9/06
1	115.7	87.6	100	113.2	1.5	131.1	97.3	131.7
2	105.1	62.4	89.6	102.9	D	100.3	D	103.4
3	87.3	67.4	87.4	91.6	112.4	99.8	90	103.6
4	74	62.7	74.8	77.2	89.3	77.5	72.2	85.2
5	74.7	59.6	76.1	83.8	2.6	S	D	102.4
6a	59.4	45.8	105.2	60.5	82.3	73.2	1.3	81.8
6b	55.6	58	28.6	85.6	4.1	76	55	76.2
6c	70.7	57.1	81	78.36	100.3	94.6	67.9	76.5
7	92.4	65	89.4	92.1	4.8	S	D	88.9
8	2936	2592	155.9	N/A	5.32	4090	3064	4358

Height x Width cm

	4/18/06		5/15/06		6/22/06		7/13/06		8/10/06		9/11/06		10/25/06		11/9/06	
Stream	Height	Width	Height	Width	Height	Width	Height	Width	Height	Width	Height	Width	Height	Width	Height	Width
1	20	46	56	43	21	39	22	46	11	47	15	32	S	S	28	36
2	6	25	26	34	16	32	9	30	D	D	6	20	D	D	15	30
3	12	23	18	28	20	23	14	29	13	26	12	24	12	24	16	24
4	51	88	99	76	50	93	57	84	45	64	50	90	56	88	79	80
5	16	52	19	46	9	16	15	27	10	16	S	S	D	D	15	36
6a	6	28	15	34	9	17	8	24	12	35	6	6	3	8	9	14
6b	6	27	8	92	2	83	6	77	6	35	9	26	3	89	6	93
6c	24	37	48	42	16	26	45	30	13	26	5	23	2	12	6	15
7	17	39	21	39	22	28	15	30	12	31	S	S	D	D	19	47
8	47	88	41	73	73	74	39	90	32	72	40	115	49	88	55	83

Velocity

	4/18/06		5/15/06		6/22/06		7/13/06		8/10/06		9/11/06		10/25/06		11/9/06	
Stream	ft/s	m/s	ft/s	m/s	ft/s	m/s	ft/s	m/s	ft/s	m/s	ft/s	m/s	ft/s	m/s	ft/s	m/s
1	1.39	0.42	5.2	1.58	3.6	1.09	2.64	0.80	0.46	0.14	1.49	0.45	0	0.00	2.69	0.82
2	0.69	0.21	5.67	1.72	2.3	0.70	1.06	0.32	D	#####	0.64	0.19	D	#####	1.6	0.48
3	0.72	0.22	1.33	0.40	1.6	0.48	0.85	0.26	1.86	0.56	0.36	0.11	0.3	0.09	0.74	0.22
4	0.62	0.19	2.27	0.69	0.6	0.18	0.55	0.17	1.8	0.55	0.46	0.14	0	0.00	1.39	0.42
5	0.14	0.04	0.83	0.25	1.4	0.42	1.39	0.42	0	0.00	S	#####	D	#####	2.82	0.85
6a	0.46	0.14	1.28	0.39	3.05	0.92	4.66	1.41	0.35	0.11	1.39	0.42	1	0.30	10.57	3.20
6b	1.28	0.39	6.28	1.90	3.5	1.06	1.18	0.36	4.17	1.26	4.16	1.26	2.1	0.64	4.94	1.50
6c	1.39	0.42	1.92	0.58	2.21	0.67	2.24	0.68	2.2	0.67	1.46	0.44	3.92	1.19	3.36	1.02
7	0	0.00	1.19	0.36	0.8	0.24	1.95	0.59	0.2	0.06	S	#####	S	#####	0.34	0.10
8	2.33	0.71	1.3	0.39	0.93	0.28	1.39	0.42	1.4	0.42	0.57	0.17	1.39	0.42	0.93	0.28

Flow (cubic meters/sec)

Stream	4/18/06	5/15/06	6/22/06	7/13/06	8/10/06	9/11/06	10/25/06	11/9/06
1	0.039	0.379	0.089	0.081	0.007	0.022	#####	0.082
2	0.003	0.152	0.036	0.009	#####	0.002	#####	0.022
3	0.006	0.020	0.022	0.010	0.019	0.003	0.003	0.009
4	0.084	0.518	0.085	0.080	0.157	0.063	0.000	0.266
5	0.004	0.022	0.006	0.017	0.000	#####	#####	0.046
6a	0.002	0.020	0.014	0.027	0.004	0.002	0.001	0.040
6b	0.006	0.140	0.018	0.017	0.027	0.029	0.017	0.084
6c	0.037	0.117	0.028	0.092	0.023	0.005	0.003	0.009
7	0.000	0.030	0.015	0.027	0.002	#####	#####	0.009
8	0.292	0.118	0.152	0.148	0.098	0.079	0.182	0.129

S: Stagnant
D: Dry

Appendix D

Chemical Stream Data 2006

Stream 1

	Total Nitrogen		Total Phosphorus		Nitrate	TKN	Ammonia
Date	ppm	ppb	ppm	ppb	ppm	ppm	ppm
4/18/2006	0.7	700	0.055	55	BRL	0.7	0.14
5/15/2006	0.63	630	0.026	26	BRL	0.63	0.041
6/22/2006	1.19	1190	0.035	35	BRL	1.19	0.052
7/13/2006	1.2	1200	0.077	77	BRL	1.2	0.12
8/10/2006	3.6	3600	0.137	137	BRL	3.6	0.57
9/11/2006	1.88	1880	0.089	89	BRL	1.88	0.21
10/25/2006	1.33	1330	0.241	241	0.1	1.23	0.12
11/9/2006	1.4	1400	0.093	93	BRL	1.4	<0.02

Stream 2

	Total Nitrogen		Total Phosphorus		Nitrate	TKN	Ammonia
Date	ppm	ppb	ppm	ppb	ppm	ppm	ppm
4/18/2006	0.8	800	0.105	105	BRL	0.77	0.44
5/15/2006	0.49	490	0.047	47	BRL	0.49	0.07
6/22/2006	1.47	1470	0.064	64	BRL	1.47	0.11
7/13/2006	2.6	2600	0.182	182	BRL	2.6	0.28
8/10/2006	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9/11/2006	1.32	1320	0.19	190	BRL	1.32	0.13
10/25/2006	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/9/2006	0.7	700	0.203	203	BRL	0.7	0.02

Stream 3

	Total Nitrogen		Total Phosphorus		Nitrate	TKN	Ammonia
Date	ppm	ppb	ppm	ppb	ppm	ppm	ppm
4/18/2006	0.4	400	0.05	50	0.12	0.28	0.18
5/15/2006	0.5	500	0.019	19	0.08	0.42	0.051
6/22/2006	1.08	1080	0.093	93	0.1	0.98	ND
7/13/2006	0.5	500	0.078	78	0.08	ND	0.051
8/10/2006	2.8	2800	0.068	68	0.06	2.7	0.19
9/11/2006	2.01	2010	0.046	46	0.13	1.88	0.12
10/25/2006	0.27	270	0.041	41	0.12	0.15	0.14
11/9/2006	0.98	980	0.047	47	BRL	0.98	0.03

Stream 4

	Total Nitrogen		Total Phosphorus		Nitrate	TKN	Ammonia
Date	ppm	ppb	ppm	ppb	ppm	ppm	ppm
4/18/2006	0.4	400	0.08	80	BRL	0.42	0.13
5/15/2006	0.7	700	0.057	57	BRL	0.7	0.037
6/22/2006	1.4	1400	0.072	72	BRL	1.4	0.059
7/13/2006	0.57	570	0.124	124	BRL	0.57	0.059
8/10/2006	1	1000	0.109	109	BRL	1	0.028
9/11/2006	0.98	980	0.066	66	BRL	0.98	0.08
10/25/2006	0.87	870	0.138	138	0.03	0.84	0.1
11/9/2006	1.82	1820	0.143	143	BRL	1.82	<0.02

Stream 5

	Total Nitrogen		Total Phosphorus		Nitrate	TKN	Ammonia
Date	ppm	ppb	ppm	ppb	ppm	ppm	ppm
4/18/2006	0	0	0.033	33	BRL	BRL	0.076
5/15/2006	0.7	700	0.025	25	BRL	0.7	0.034
6/22/2006	1.82	1820	0.051	51	BRL	1.82	0.15
7/13/2006	2	2000	0.163	163	BRL	2	0.29
8/10/2006	8.3	8300	0.079	79	BRL	8.3	0.96
9/11/2006	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/25/2006	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/9/2006	1.4	1400	0.077	77	BRL	1.4	0.02

Stream 6a

	Total Nitrogen		Total Phosphorus		Nitrate	TKN	Ammonia
Date	ppm	ppb	ppm	ppb	ppm	ppm	ppm
4/18/2006	0.4	400	0.092	92	BRL	0.42	0.046
5/15/2006	0.49	490	0.044	44	BRL	0.49	ND
6/22/2006	1.89	1890	0.093	93	BRL	1.89	0.11
7/13/2006	0.5	500	0.407	407	BRL	ND	0.064
8/10/2006	5.1	5100	0.271	271	BRL	5.1	0.12
9/11/2006	2.55	2550	0.119	119	BRL	2.55	0.21
10/25/2006	0.5	500	0.118	118	BRL	0.5	0.08
11/9/2006	0.7	700	0.09	90	BRL	0.7	0.03

Stream 6b

	Total Nitrogen		Total Phosphorus		Nitrate	TKN	Ammonia
Date	ppm	ppb	ppm	ppb	ppm	ppm	ppm
4/18/2006	0.6	600	0.098	98	BRL	0.63	0.1
5/15/2006	0.63	630	0.048	48	BRL	0.63	0.032
6/22/2006	0.91	910	0.085	85	BRL	0.91	ND
7/13/2006	1.2	1200	0.517	517	BRL	1.2	0.13
8/10/2006	0.5	500	0.303	303	BRL	ND	0.58
9/11/2006	0.59	590	0.1	100	BRL	0.59	0.07
10/25/2006	0.39	390	0.078	78	BRL	0.39	0.08
11/9/2006	0.56	560	0.09	90	BRL	0.56	0.03

Stream 6c

	Total Nitrogen		Total Phosphorus		Nitrate	TKN	Ammonia
Date	ppm	ppb	ppm	ppb	ppm	ppm	ppm
4/18/2006	0.5	500	0.15	150	BRL	0.49	0.15
5/15/2006	0.35	350	0.039	39	BRL	0.35	ND
6/22/2006	0.42	420	0.062	62	BRL	0.91	ND
7/13/2006	0.63	630	0.097	97	BRL	0.63	0.055
8/10/2006	0.55	550	0.082	82	BRL	0.55	0.14
9/11/2006	7.56	7560	0.113	113	BRL	7.56	0.11
10/25/2006	2.1	2100	0.092	92	BRL	2.1	0.2
11/9/2006	0.56	560	0.087	87	BRL	0.56	0.02

Stream 7

	Total Nitrogen		Total Phosphorus		Nitrate	TKN	Ammonia
Date	ppm	ppb	ppm	ppb	ppm	ppm	ppm
4/18/2006	1	1000	0.167	167	BRL	1.05	0.27
5/15/2006	0.98	980	0.048	48	BRL	0.98	0.056
6/22/2006	3.15	3150	0.317	317	BRL	3.15	0.47
7/13/2006	1.8	1800	0.121	121	BRL	1.8	0.15
8/10/2006	3.1	3100	0.191	191	BRL	3.1	1
9/11/2006	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10/25/2006	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11/9/2006	2.38	2380	0.203	203	BRL	2.38	0.04

Stream 8

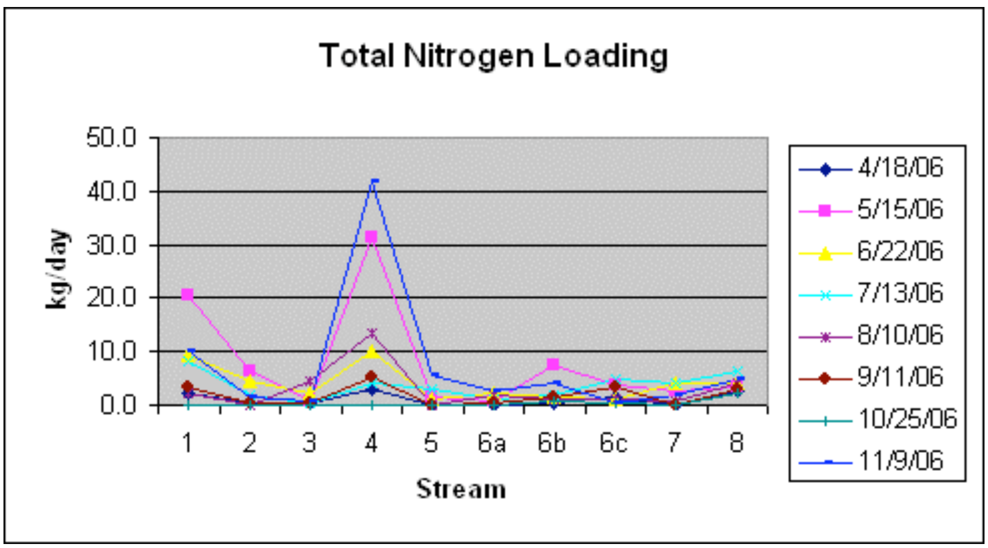
	Total Nitrogen		Total Phosphorus		Nitrate	TKN	Ammonia
Date	ppm	ppb	ppm	ppb	ppm	ppm	ppm
4/18/2006	0.1	100	0.222	222	BRL	0.14	0.022
5/15/2006	0.34	340	0.189	189	0.06	0.28	ND
6/22/2006	0.3	300	0.254	254	0.02	0.28	ND
7/13/2006	0.5	500	BRL	N/A	BRL	ND	0.024
8/10/2006	0.5	500	0.282	282	BRL	ND	ND
9/11/2006	0.42	420	0.268	268	BRL	0.42	0.08
10/25/2006	0.15	150	0.225	225	0.05	0.1	0.1
11/9/2006	0.42	420	0.18	180	<0.01	0.42	0.02

BRL: Below Reportable Limit
ND: Below Detectable Limit
N/A: Not Applicable - Stream Dry or With Out Flow

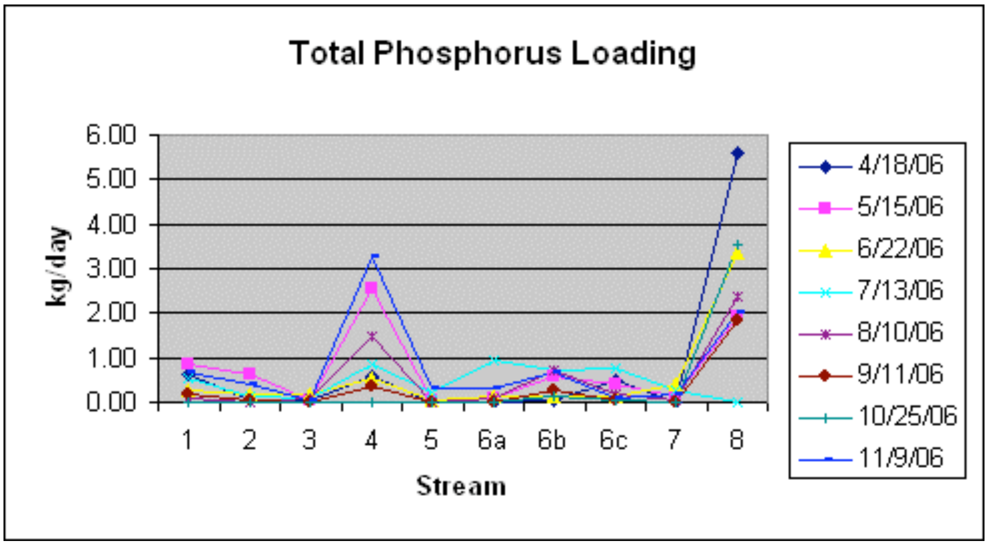
Appendix E

Steam Loading
2006

	Total Nitrogen Loading (kg/day)							
Stream	4/18/06	5/15/06	6/22/06	7/13/06	8/10/06	9/11/06	10/25/06	11/9/06
1	2.3	20.7	9.2	8.4	2.2	3.5	#VALUE!	9.9
2	0.2	6.4	4.5	1.9	#VALUE!	0.3	#VALUE!	1.3
3	0.2	0.9	2.1	0.5	4.6	0.5	0.1	0.7
4	2.9	31.3	10.2	3.9	13.6	5.3	0.0	41.9
5	0.0	1.3	1.0	2.9	0.0	#VALUE!	#VALUE!	5.6
6a	0.1	0.8	2.3	1.2	2.0	0.3	0.0	2.4
6b	0.3	7.6	1.4	1.7	1.1	1.5	0.6	4.0
6c	1.6	3.5	1.0	5.0	1.1	3.3	0.5	0.4
7	0.0	2.5	4.1	4.1	0.6	#VALUE!	#VALUE!	1.9
8	2.5	3.5	3.9	6.4	4.2	2.9	2.4	4.7



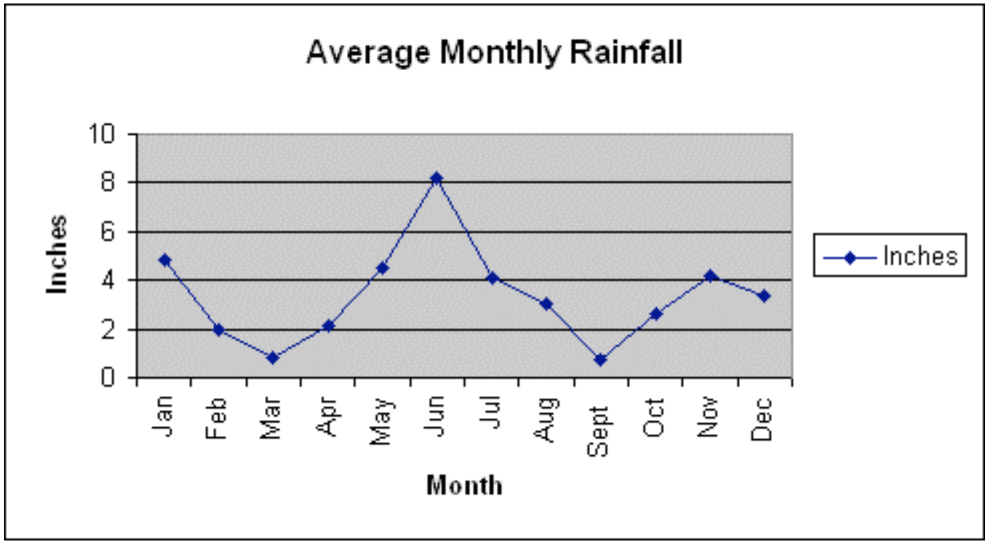
Stream	4/18/06	5/15/06	6/22/06	7/13/06	8/10/06	9/11/06	10/25/06	11/9/06
				Total Phosphorus Loading (kg/day)				
1	0.61	0.85	0.27	0.54	0.09	0.17	#VALUE!	0.66
2	0.03	0.62	0.20	0.14	#VALUE!	0.04	#VALUE!	0.38
3	0.03	0.03	0.18	0.07	0.11	0.01	0.01	0.03
4	0.58	2.55	0.53	0.85	1.48	0.36	0.00	3.29
5	0.01	0.05	0.03	0.24	0.00	#VALUE!	#VALUE!	0.31
6a	0.02	0.08	0.11	0.95	0.10	0.02	0.01	0.31
6b	0.05	0.58	0.13	0.74	0.69	0.25	0.11	0.65
6c	0.48	0.40	0.15	0.77	0.16	0.05	0.02	0.07
7	0.00	0.12	0.41	0.28	0.04	#VALUE!	#VALUE!	0.16
8	5.60	1.93	3.34	#VALUE!	2.38	1.84	3.53	2.00



Appendix F

Average Monthly Rainfall
2006

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Inches	4.86	1.98	0.85	2.13	4.5	8.23	4.07	3.05	0.76	2.6	4.19	3.32



Total Rainfall: 40.54 "